Implementation Strategies for USB Circuit Protection

By Adrian Mikolajczak

The USB specification requires current limiting and/or power switching for USB power management, and references resettable polymeric positive temperature coefficient (PPTC) devices and solid-state switches as acceptable methods for overcurrent protection. Resettable current limiting in a fault condition helps prevent circuit damage and associated system failure, and helps the system meet UL safety standards.

Like fuses, PPTC devices help protect circuitry from overcurrent damage. Unlike fuses, however, they reset when the circuit is de-energized and the fault is removed. Protected power switch devices integrate resettable current limiting functionality with power switching, and are most commonly used in bus-powered hubs, in dual-mode hubs, and in low-power hosts. They function as inrush current limiting devices, and combine low resistance with extremely fast current limiting. They are a practical, cost-effective solution for power-constrained hosts where a fast current limiting response further reduces system voltage droop in a fault condition, and where power switching can be used to improve energy conservation.

Industry Specification Requirements

The USB specification states that current limiting, power switching, or both may be required in a USB product, as shown in Figure 1. Where current limiting is required, the UL 60950 specifications must be met. This means that in the event of a short circuit or other fault condition, current output must be limited to below 5A within 60 seconds. The USB specification also defines acceptable voltage output levels and limits total voltage drop in the system.

Protected Power Switch Technology

Protected power switch devices are silicon series elements used in the USB power bus to control the flow of power to ports and to protect circuitry and devices from damage caused by overcurrent. Like the PPTC device, the protected power switch trips in an overcurrent condition, but it does so in a two-phased approach. The device 'trips' in microseconds, limiting current to a predefined range that is higher than nominal operating current, and then flags the controller that a fault condition has occurred. The controller can then shut down the port by toggling the enable pin on the power switch. If the controller does not respond, the power switch cycles the port on and off to prevent thermal damage.

Parameters

The critical device parameters in USB applications include switch resistance, continuous output current, time-to-trip, current limit set point, fault flag delay, current limit release point, and tripped current draw.

Switch Resistance

Switch resistance can affect both system power draw and the end-user experience, and is measured through the device when it is not in current limiting mode. High switch resistance can result in excessive voltage drop through the device, which can result in USB non-compliance and improper device functionality. Silicon switch resistance can be a function of supply voltage, and the best device will minimize resistance and voltage drop at lower bus voltages in order to maintain USB output voltage compliance.

Continuous Output

Continuous output current is the current level at which the device will not trip. For systems with low wattage power supplies this should be set as low as possible while still supporting the USB specification. This will help minimize voltage drop in short circuit conditions.

Time-to-Trip

Time-to-trip defines the speed at which a protected power switch device activates its current limiting circuitry. The extremely fast time-to-trip of the silicon device makes it the preferred choice for power-constrained applications. Unlike the PPTC device, however, post trip current levels can remain fairly high, and are defined by the current limit set point.

Current Limit Set Point

The current limit set point is the level at which a silicon device will limit current once it has tripped. Its value can vary depending on the severity of the fault condition, and is typically defined as a function of the fault condition's resistance. For low-power applications, the current limit should be specified as low as possible.

Fault Flag Delay

Integrating a fault flag delay with the silicon device helps prevent 'nuisance tripping' and improves the end-user experience. The fault flag is a logic level output that alerts the USB controller when there is a problem with a specific USB port. During USB hot plug events, many USB functions are highly capacitive and can draw significant current, exceeding specification limits. This causes the device to trigger a short-lived current limiting condition that, if signaled to the controller, will cause nuisance tripping. A 9-millisecond fault flag delay prevents these short-lived events from triggering the fault flag.

USB Device	Overcurrent Protection[1]	Power Switching[1]
Host Controller	Required	Optional
Self-powered Hub	Required	Optional
Bus-powered Hub	Optional	Required
Dual-Mode Hub[2]	Required	Required

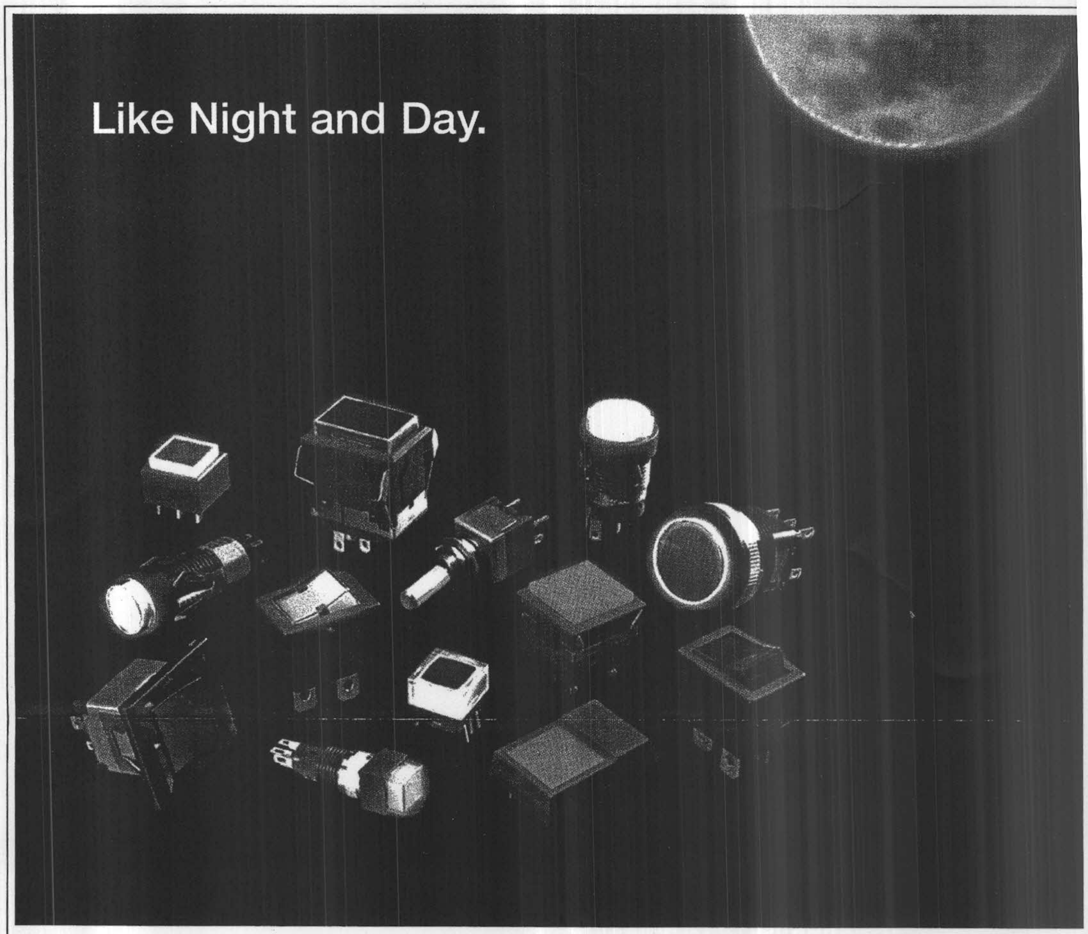
1: May be designed in either a ganged or individual port basis
2: Dual Mode Hubs can function as both powered or Bus-Powered Hubs

Figure 1. Circuit protection and power switching requirements for USB.

Current Limiting Release Point

The current limiting release point is a critical parameter for the end-user experience. This is the current level at which the silicon device will disengage its current limiting function. This is an important design consideration because once current limiting is active the device resistance is dramatically increased and may prevent proper functioning of an attached USB device. If set too low, a device that enters current limiting mode during hot-plug may remain tripped when initial inrush currents subside, preventing proper USB function operation. By setting current limiting release points above 500 mA, the protected power switch will cease to limit current once the USB device returns to normal operating current levels.

(Continued on page 24)

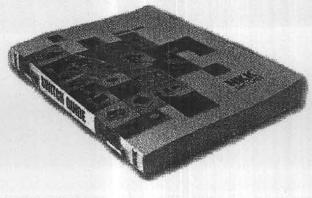


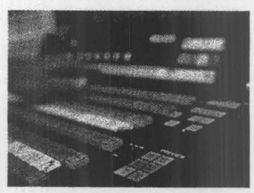
For the most reliable illuminated switches, NKK is the brightest choice. NKK Switches is the leader in illuminated switches, offering a wide variety of pushbuttons, rockers, toggles, tactiles and slides in micro-subminiature to standard sizes. And all of our illuminated switches come with a wide variety of color, illumination and mounting options.

The high stability and long life of this switch line is complemented by its aesthetic appeal and flexibility in design applications.

With more than 50 years experience in developing innovative, high-quality switches, NKK's illuminated line makes other switches pale in comparison.

Log on or call 480.991.0942 today for your FREE copy of the new Switch Guide.





NKK® SWITCHES

Excellent Contacts Pay Off

http://ce.nkkswitches.com

Switches & Relays

USB Circuit Protection

(Continued from page 23)

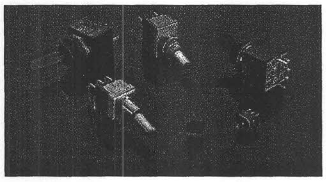
Tripped Current Draw

Initial power dissipated at the port after a trip event is a function of the silicon device's limit current. If the device can be turned off during a fault condition, port current draw and power draw are negligible. If, however, control circuitry is not implemented (e.g. the enable pin is tied high in a high enable device, or power switching is not integrated into the device) most silicon devices will continue to limit current until they reach an internal temperature threshold. When the temperature threshold is reached they will begin to thermally cycle the port on and off. Average port current draw under these conditions will be a function of the thermal duty cycle, and the current limit. For low-power applications using silicon devices, it is important to implement proper on/off control circuitry to prevent high, 'tripped' power dissipation.

Summary

Protected power switches can integrate numerous detection and protection functions in USB power management applications, resulting in improved performance and reduced component count. Specifying the appropriate device requires consideration of several critical device parameters to provide system reliability, and meet end-user expectations.

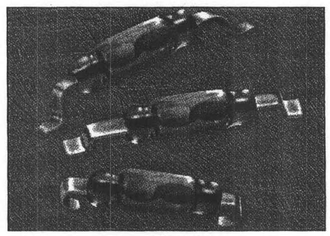
Adrian Mikolajczak is multimedia market manager at Tyco Electronics Power Components/Raychem Circuit Protection Group. **Circle CE 256**



ILLUMINATED TOGGLE SWITCHES

The G series of ultra-miniature illuminated toggles are process compatible, fully lighted toggles. The light weight of this series makes it suitable for front-panel or handheld devices. The toggle actuator is manufactured in a clear polyamide, enabling the LED color to fully illuminate through the entire actuator with a bright, jeweled appearance. This feature allows for highly visible status indication.

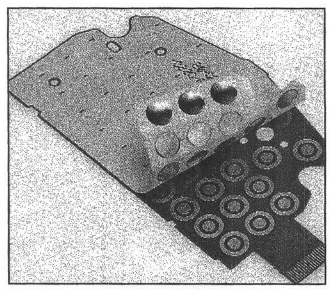
NKK Switches **Circle CE 266**



SMT REED SWITCHES

The RI-80, ultra-miniature SMT switches, with 5 mm max glass length, feature a wide flat lead design to provide both stability during component placement and improved solderability for surface mounted applications. The RI-80SMD is available in three different Gull or 'J' lead configurations. The J leaded version with .279" (7.1 mm) is said to be the smallest SMT reed switch sensor available in the industry. The RI-80SMD is rated at 5W, packaged in tape and reel to facilitate automated processing.

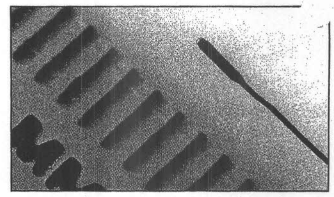
Coto Technology **Circle CE 268**



DOME DOES 2.5M OPERATIONS

4mm diameter dome is capable of up to 2.5 million operations. The 2.5 million operational lifecycle domes have a click ratio of 45 % ensuring good positive feel, with minimal noise. They are available separately, or the company can supply them as arrays, or fully assembled as keypads with associated PCBs and illumination, produced in its ISO 900:2000 facilities. Key to the performance of these long-life dome switches is the high quality materials used and the manufacturing test methodology employed.

ITT Industries, Cannon **Circle CE 269**



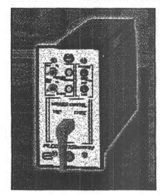
THERMISTOR PROBE

With a time response of 30 milliseconds (in liquids), this probe is suitable for a range of instrumentation and medical applications, where thermistor response times are critical. Examples include catheters, hypodermic needles and applications demanding the measurement of small volumes of liquids and gases. The small size of the thermistor (0.014 inches O.D.) also makes it ideal for insertion into small housings, larger instrumentation or analytical equipment.

Betatherm Sensors **Circle CE 257**

CONTROL INDICATOR MODULE SCADA COMPATIBLE

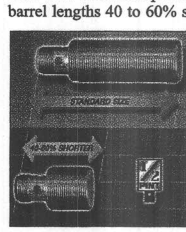
This control indicator module (CIM) conta[illegible] SCADA interface for remote control and m[illegible]toring of power circuit breakers and reclosers. Switches on the unit's front panel permit manual control when needed. The unit's RS-485 interface allows the use of DNP 3.0, Modbus, or other compatible communications protocols. A simple 8-bit parallel interface is also available.



Electroswitch **Circle CE 259**

INDUCTIVE PROXIMITY SENSORS

Half Pint inductive proximity sensors feature barrel lengths 40 to 60% shorter than traditional models, but do not sacrifice performance. Half Pint technology integrated within standard Basic Series, X-Series (extended range) and Pile Driver (stainless steel sensing face) sensor families cr[illegible] a broad offering of space saving cylindrical products. These 3-wire DC sensors are offered in pre-leaded and quick-disconnect versions, and are fully flush mountable.

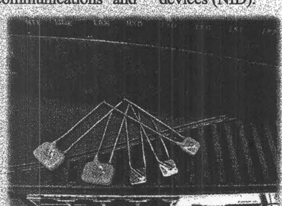


Pepperl+Fuchs **Circle CE 273**

Feature Product

Resettable Fuse Protects Telecom, Network Equipment

The Polyfuse HVR250is a polymer-based positive temperature coefficient (PPTC) device, designed to protect telecommunications and networking equipment against lightning strikes and power crosses.



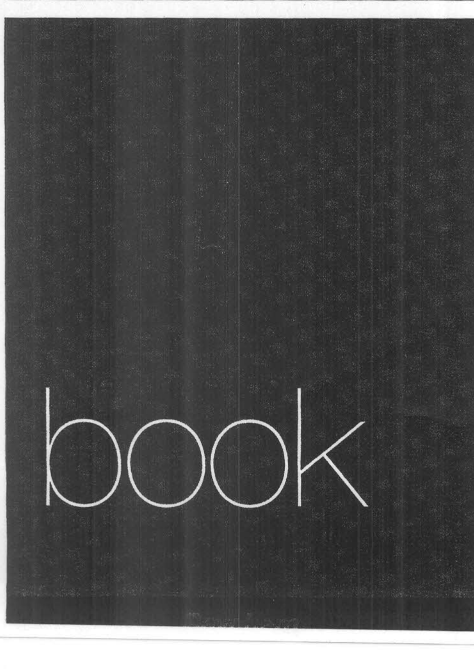
The HVR250 resettable fuses are optimized to provide overcurrent for xDSL and ISDN modems, splitters, and MDF equipment that must comply with ITU K.20, K.21, K.45 and Telcordia GR-974 requirements. K.20 addresses central office switching equipment including line cards, modems, splitters and multiplexers, whereas K.21 specifies requirements for customer premises equipment including modems, fax machines, caller ID boxes, voice over IP appliances and PBX equipment.

K.45 covers the requirements and procedures for equipment installed between a central office and customer premises. Telcordia GR-974 outlines the requirements for main distribution frame (MDF) modules and network interface devices (NID).

Overvoltages, which are typically caused by lightning surges or AC power faults, are usually limited by using gas tube surge arresters or varistors. However, this can produce high fault currents that may overload the protective circuitry and overheat the tip and ring lines on the equipment's input, resulting in damaged components and failed equipment. HVR250 fuses protect the equipment from induced current conditions and automatically resets after correction of the fault, reducing the equipment service costs.

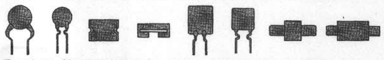
The HVR250 is available in coated and uncoated versions with hold currents from 80 to 180mA. The HVR250 is designed to withstand a maximum of 250VAC interrupting voltage.

Wickmann **Circle CE 285**



WHEN YOU'RE LOOKING TO BUILD SAFETY, RELIABILITY AND VALUE into your product, the Raychem Circuit Protection Databook is the only resource you'll ever need. In it you'll find an unrivaled portfolio of overtemperature, overcurrent, and overvoltage solutions including SiBar thyristor surge protectors, ROV radial-leaded metal oxide varistors, and telecom fuses, as well as the entire family of PolySwitch resettable devices that have been built into billions of electronic products.

In 1980, Raychem pioneered the development of PPTC (Polymer Positive Temperature Coefficient) resettable device technology.



Raychem Circuit Protection remains dedicated to simplifying and improving electrical systems across a spectrum of markets, including telecommunications, computing, portable electronics, consumer electronics, automotive, and industrial.

We take great pride in our ability to deliver world-class customer service, comply with globally recognized quality standards, and provide local engineering support while remaining cost competitive.

If you don't already have the world's most comprehensive book on circuit protection (or just want to make sure you own the most recent version), order your free copy by calling **1-800-227-7040 / 650-361-6900** or by visiting us at **www.circuitprotection.com/databook**

tyco / Electronics